

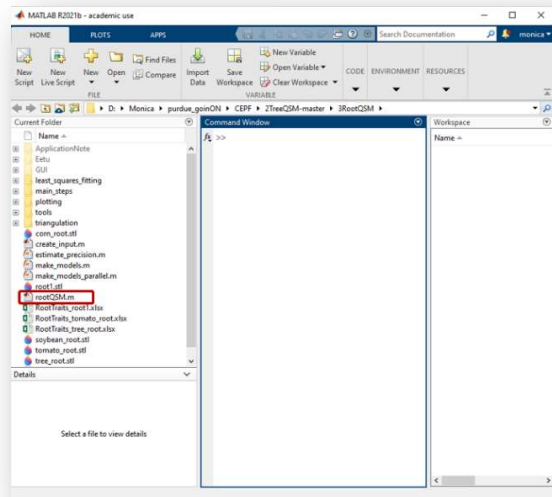
4DROOT SOFTWARE

INSTALL FROM MATLAB:

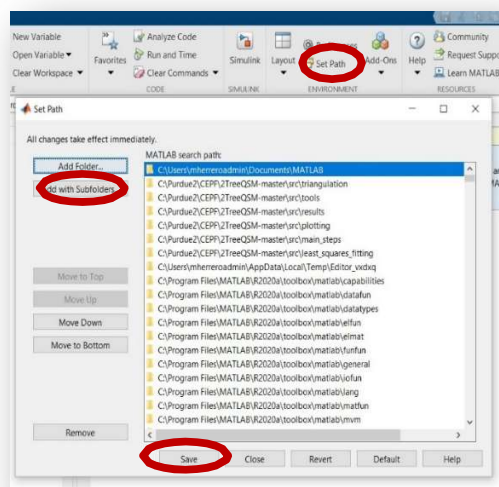
- COMPUTER VISION TOOLBOX
- PARTIAL DIFFERENTIAL EQUATION
- STATISTICS AND MACHINE LEARNING TOOLBOX

INSTRUCTIONS: CODE FOR MODELING THE ROOTS

1. Download 4DRoot
2. Start MATLAB 2017 or newer and set the main path to the root folder, where rootQSM.m is located (from 4DRoot).

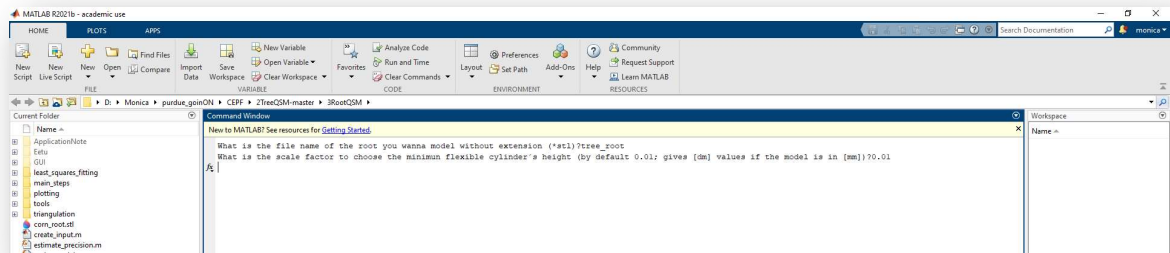


3. Use Set Path -> Add with Subfolders -> Open -> Save -> Close to add the subfolders, where all the code of the software is, to the paths of MATLAB.

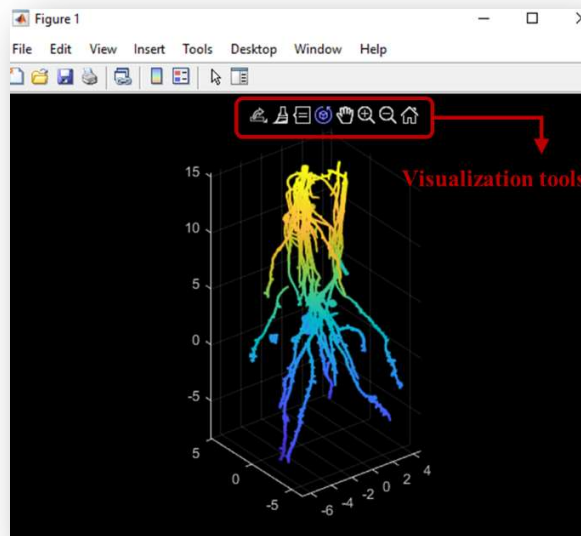


4. Run rootQSM.m:

4.1. Inputs: 3D scan of the root in *.stl format, factor scale to reconstruct the cylindrical fitting (0.01 by default) and desire to view the 3Dscan.

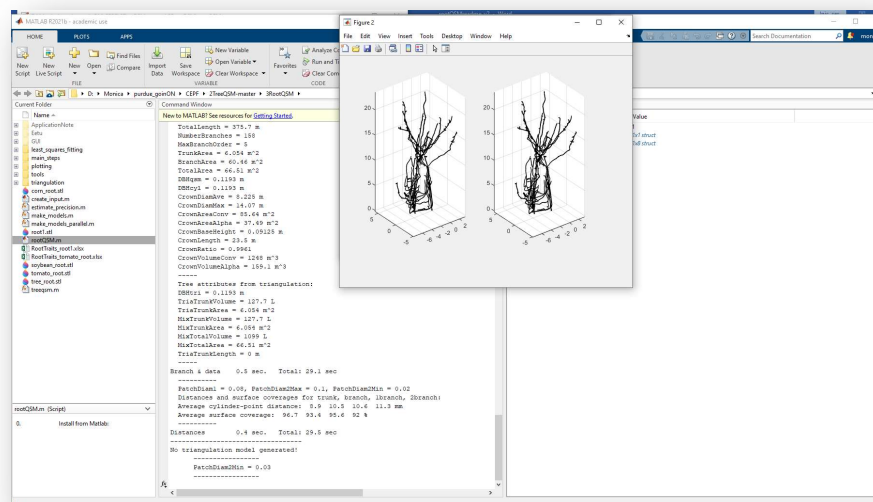


4.2. Visualization of the 3D scan as an option. Visualization tools are included.



After the visualization, the process is paused. To continue, press any key.

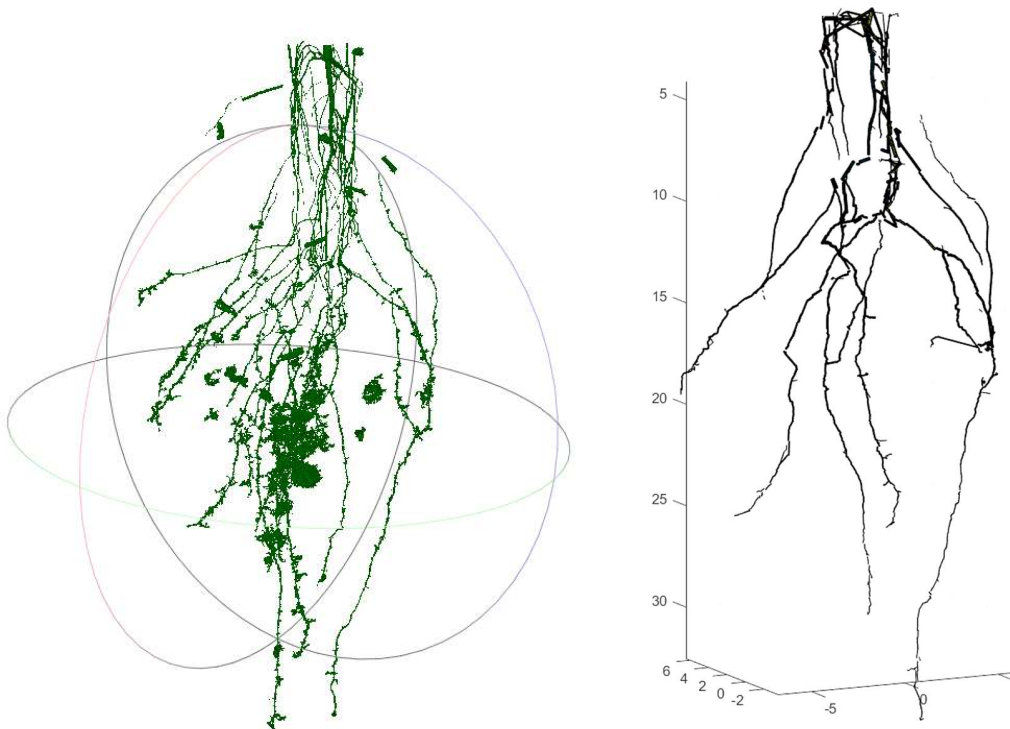
4.3. Numerical and graphic results of each approximation of the cylindrical model (upside down) when 3D Root is running.



4.4. Output: Phenotypic root traits and their distribution are extracted to an excel file with several sheets.

TRAITS	Value
TotalVolume*10 ⁻³ (dm ³)	169.5274274
PrimaryRootVolume*10 ⁻³ (dm ³)	120.747123
LateralRootVolume*10 ⁻³ (dm ³)	48.5497052
TotalRootHeight(dm)	6.81144934
TotalLength(dm)	45.5259713
PrimaryRootLength(dm)	7.15442225
LateralRootLength(dm)	38.3765594
NumberOfRamifications	28
Max.Ramif.Order	3
TotalArea(dm ²)	7.02940543
PrimaryRootArea(dm ²)	2.81437703
LateralRootArea(dm ²)	4.21482746
CrownDiam(dm)	3.33842782
CrownDiam(dm)	6.91124799
CrownAreaCone(dm ²)	29.65122209
CrownAreaAlphaShape(dm ²)	5.78743892
CrownAreaBetaShape(dm ²)	6.34651120
CrownLength(dm)	6.46612903
CrownRatio	0.34932046
CrownVolumeCone*10 ⁻³ (dm ³)	31.94447
CrownVolumeAlpha*10 ⁻³ (dm ³)	2.1892756
Location x	6.18327926
Location y	0.98175965
Location z	-2.96523195

***Noise removal:** noise from the segmentation between soil and root can be removed by 4DRoot by choosing an appropriated *factor scale* (left: 3D scan from a root, right: QSM from the root).



CITE:

1. Raunonen P, Kaasalainen M, Åkerblom M, Kaasalainen S, Kaartinen H, Vastaranta M, et al. Fast automatic precision tree models from terrestrial laser scanner data. *Remote Sens.* 2013;5(2):491–520.
2. Herrero-Huerta, M., Meline, V., Iyer-Pascuzzi, A. S., Souza, A. M., Tuinstra, M. R., & Yang, Y. (2021). 4D Structural root architecture modeling from digital twins by X-Ray Computed Tomography. *Plant Methods*, 17(1), 1-12.